Literature Review

2.1 Water as Economic Good

The concept of water as an economic good can be derived from the definition of economics, which is the study of

"How societies use scarce resources to produce valuable commodities and distribute them among different groups[9]."

Water is an economic resource since it not only meets the basic needs of human being but also has many competing uses such as industry and agriculture. Water is scarce since it cannot meet the demands of all the competing uses simultaneously in time and space. The trend to treat water as an economic good developed in the economic literature in 20th century and found place in the International Conference on water and the Environment in Dublin, Ireland in 1992 where it was stated that:

"Water has an economic value in all its competing uses and should be recognized as an economic good[10]"

In spite of this water resources have seldom been viewed as an integral part of the economy. Many analytical developments are problem-driven. Despite earlier efforts, the integration of water into the macro economy has been rather unsatisfactory as water does not have a closed cycle in any of the Input/output studies. The sectorial or spatial segregation is usually too lumped making decision-making

[9] Economics, Samuelson, P.A. et al., 1989, p5
[10] The Dublin Statement on Water and Sustainable Development, conference report, 1992

impracticable. The most studied aspect of water is the drinking water which is considered as a service thereby ignoring its true value and price in the economy. The two-way link of water resources decision-making and macroeconomic decision-making were not explicitly considered. This lack of integration may be puzzling, especially as attempts have been made to examine other scarce resources such as energy in such a linked macroeconomic context. However, it is also a fact that much of the energy-economy links took place as a response to the oil crisis of the 1970s. As water scarcity is now approaching crisis situations in many areas, interest has been generated for its inclusion in the macro economy.

In the first major modern economic treatise specifically on water, Eckstein (Eckstein, 1958) generally assumed that water was important to the economy and did not see any particular need to explain why water was important in the functioning of the economy. Subsequent book by Maass et al. (Maass, 1962) also took it for granted that water was an important ingredient of national economic planning. This literature, based upon classical economic growth models, made no real distinction about water other than its nature as a fugitive resource and that significant externalities were generated in the use of water in the economy.

At a fundamental level water has only two uses: first, and foremost, sustaining the ecosystems; and second as a natural resource for humankind. All other uses can be subsumed under these two. In an ecosystem there are no "surplus" materials. Water is just re-allocated between species. This raises the economic concept of "opportunity cost." Water is said to have an "opportunity cost" since the continued withdrawal by one user reduces the amount available to another. This lost "opportunity" costs the affected user the amount he values these units of water.

At this point the "value" of the water should reflect the willingness-to-pay of the user who is losing water (Rogers P. , 1997).

Establishing the willingness-to-pay for various consumers of water is a fairly well developed and can be easily adapted in many water conflict situations to establish estimates of the opportunity cost of water for many of the direct uses of water which have marketable properties. But it is difficult to conceptualize and measure, some of the opportunity costs associated with environmental services provided by water. Many economic studies of water use ignore the opportunity cost of water and only reflect the actual costs of obtaining the water itself. If there were well-established markets for water then the market price would itself reflect the opportunity cost of water. However, in most countries such markets do not exist and one is left to estimate the opportunity cost in indirect ways (Rogers P. , 1997).

The opportunity cost of water is only zero when there is no shortage of water. In evaluating water investments it is important to remember that the value of water to a user is the cost of obtaining the water plus the opportunity cost. Ignoring the opportunity cost part of value will undervalue water, lead to failures to invest, and cause serious mis-allocations of the resource between users. The opportunity cost concept also applies to issues of water and environmental quality. In planning for development of the economy three values are in conflict; allocation of resources to their most productive uses (efficiency); distribution of the outputs of production to various individuals and social groups within the economy (justice); and the scale (the size) of the entire economy (sustainability).

2.2 Economics of Sustainability

Many economists (OECD, 1995) view the environment as a form of natural capital that must be preserved. They distinguish three types of capital;

(i) Man-made capital - Factories, roads, housing, machinery, etc., which can be expanded or decreased by human effort;

(ii) Critical natural capital - Ozone layer, global climate, biodiversity, Antarctica, etc. which is made up of natural assets essential for ecosystem survival that cannot be replaced (or at least not without great difficulty) or substituted for by man-made capital assets; and

(iii) Other natural capital - renewable natural resources and other finite resources that can be partially or wholly substituted for by products of man-made capital assets.

The problems for economic theory lie with how to deal with the other natural capital. For the critical natural capital category the prescription is clear i.e. these are vital, irreplaceable, beyond price and their preservation should be an absolute constraint on all activities. Is water a critical natural resource or just other natural resource? Unfortunately, it appears to be both. It is essential for human and eco-system survival but its use in many activities can be substituted for by man-made capital. This dualism causes much confusion in discussing the rational economic development of water resources.

It also prescribes guiding principles for sustainable development as:

(1) Let future generations have as much access to our resources as we do.

(2) Do not discount for future welfare.

(3) Minimize consumption of exhaustible resources.

(4) Maintain current stocks of renewable resources.

Sustainability requires that the stock of capital that is available for future generations be equivalent to that available at present. If this is to be truly followed, the present generation would consume no non-renewable resources today as we spread these scarce resources out over an essentially infinite horizon. To overcome this dilemma the concept of strong and weak sustainability has been advocated basing on the force of its interpretation (Turner, 1993) as brought out by FAO. As per this the weak sustainability requires that the total stock of capital, human-induced and natural, be maintained, and it assumes substitutability between the two types of capital. As a natural resource becomes depleted, the price increases; this encourages more efficient resource use, substitution with other goods, and technological advancement. However, complete substitution is not necessarily practicable or possible, for example, because of the absence of substitutes for some forms of capital (e.g. critical natural capital), and inadequacy of substitutes (e.g. for complex ecosystems).

Daly, 1995 as quoted by FAO mention that strong sustainability requires that the total stock of natural capital not be depleted. Natural and human-induced capital are regarded as complements not substitutes and stocks of both must be maintained. Consequently, activities are required to conserve the natural environment, or to ensure that any losses incurred are replaced or compensated for fully in physical terms through 'shadow projects' (Barbier, Markandya and Pearce, 1990 as reported by FAO (Brouwer, 2004)). The emerging approach to water governance is seeking to adopt a stronger sustainability approach, one guided by principles of stewardship, equity and accountability. The result will be to constrain the mindset and market mechanisms that treat water as a commodity in its various functions and seek to establish an efficient allocation of water among competing end uses. Efficiency is a necessary but not sufficient condition for sustainability, but exactly how constraining sustainability standards ought to be remains an open scientific and policy question.

If the economic impacts of all the pollution and other unaccounted-for externalities to the system defined were really reflected in the prices of resources, then classical economic theory would lead us to a *Full-Cost Pricing* system. In the case of pollution, this can be restated as the *Polluter-Pays* Principle and can be achieved by environmental regulations and economic incentives for pollution prevention. But for resource use, the formulation is the *User-Pays* Principle.

2.3 Economic Criteria for Achieving Sustainable Development:

In 'Our Common Future[11]', the SD was defined as:

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

However in practice the SD has been defined on the following criteria:

(1) Place economic values on environmental costs and benefits (The User-Pays and Polluter-Pays Principles);

(2) Avoid damage to critical natural capital as far as possible (The Precautionary Principle);

(3) Avoid irreversible processes;

(4) Limit the use of renewable natural assets to their sustainable yield; Otherwise, include the costs of replacing these assets, e.g. through a "compensatory" project.

While it is true that market mechanisms may be more efficient than traditional command and control regulations, however, it is not reasonable to expect private profit maximizers to be entrusted with the responsibility of keeping the welfare of future generations in mind. It is possible, however, to let market mechanisms work to implement innovative approaches to environmental management,

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11 Also known as Brundtland Report.

such as tradable permits. The problem is that these approaches have limited applications; in addition, the cost of tradable permits is not easily pre-determined. Effluent charges and taxes would also encourage innovation and efficiency as compared to more traditional regulations, but there would be uncertainty in the amount of environmental improvement achieved. Market mechanisms are extremely difficult to implement in the face of the large uncertainty in the emissions, the standards and the costs, efficiencies, and reliabilities of control technologies. This is where the need for government intervention is clear.

2.4 Economics of Water Scarcity

As per UNDP[12] around one fifth of the world's population currently live in regions affected by physical water scarcity (UNDP, 2006), where there is inadequate water resources to meet a country's or regional demand, including the water needed to fulfill the demand of ecosystems to function effectively. Arid regions frequently suffer from physical water scarcity. It also occurs where water seems abundant but where resources are over-committed, such as when there is over development of hydraulic infrastructure for irrigation. Symptoms of physical water scarcity include environmental degradation and declining groundwater as well as other forms of exploitation or overuse (UNDP, 2006).

Economic water scarcity is caused by a lack of investment in infrastructure or technology to draw water from rivers, aquifers or other water sources, or insufficient human capacity to satisfy the demand for water. One quarter of the world's population is affected by economic water scarcity. Symptoms of economic water scarcity include a lack of infrastructure, causing the people without reliable access to water, have to travel long distances in or fetch water that is often contaminated

[12] United Nations Development Programme (UNDP), New York

from rivers for domestic and agricultural uses. Large parts of Africa suffer from economic water scarcity; developing water infrastructure in those areas could therefore help to reduce poverty. Critical conditions often arise for economically poor and politically weak communities living in already dry environment.

One of the most commonly used measures of water scarcity is the '*Falkenmark indicator*' or '*water stress index*'. This method defines water scarcity in terms of the total water resources that are available to the population of a region; measuring scarcity as the amount of renewable freshwater that is available for each person each year. If the amount of renewable water in a country is below 1,700 m3 per person per year, that country is said to be experiencing water stress; below 1,000 m3 it is said to be experiencing water scarcity; and below 500 m3, absolute water scarcity (Falkenmark M. J., 1989).

Though this method is commonly used it has certain limitations like: (1) It ignores important regional differences in water availability, only measuring water scarcity at a country level; (2) It fails to account for whether or not those water resources are accessible, for example, some of the freshwater resources of a country may be stored deep underground or may be heavily polluted; (3) It does not include man-made sources of freshwater such as desalination plants which increase water availability beyond what is naturally available; (4) It does not account for the fact that different countries, and regions within countries, use different amounts of water, in Australia for example, most of the demand for water is focused around the major urban and agricultural centers in the Murray-Darling Basin, with much less used in the sparsely populated center (White, 2012).

An alternative way of defining and measuring water scarcity is to use a '*Criticality Ratio*'. This approach relaxes the assumption that all countries use the same amount of water, instead defining water scarcity in terms of each country's water demand compared to the amount of water available; measuring scarcity as the proportion of total annual water withdrawals relative to total available water resources (Raskin, 1997). Using this approach, a country is said to be water scarce if annual withdrawals are between 20-40% of annual supply, and severely water scarce if they exceed 40%.

This approach also has its limitations like: (1) It does not consider man-made increases in water supply (such as desalination); (2) It ignores water withdrawals that are recycled and reused; (3) It doesn't consider the capacity of countries to adapt to lower water availability through changing behavior or new technology (Rijsberman, 2006).

A third measure of water scarcity was developed by the IWMI[13]. This approach includes each country's water infrastructure, such as water in desalination plants, into the measure of water availability; including recycled water by limiting measurements of water demand to consumptive use rather than total withdrawals; and measuring the adaptive capacity of a country by assessing its potential for infrastructure development and efficiency improvements (Seckler, 1998). Using this approach, the IWMI classifies countries that are predicted to be unable to meet their future water demand without investment in water infrastructure and efficiency as economically water scarce; and countries predicted to be unable to meet their future demand, even with such investment, as physically water scarce (Molden, 2007).

[13] International Water Management Institute (IWMI) at Colombo, Sri Lanka

While the IWMI measure of water scarcity is more sophisticated, its complexity means that it requires significant amounts of time and resources to estimate. This approach also fails to consider the ability of people within countries to adapt to reduced water availability by importing food grown in other countries (i.e. virtual water), or by using water saving devices. The ability to adapt also depends on the economic resources available in countries as a whole, as well as to individuals within a country. For instance, wealthy residents in rich countries are more likely to be able to adapt to reduced water availability than poor people in developing countries.

A fourth approach to measuring water scarcity is the '*water poverty index*'. This approach attempts to take into account the role of income and wealth in determining water scarcity by measuring: (1) the level of access to water; (2) water quantity, quality, and variability; (3) water used for domestic, food, and productive purposes; (4) capacity for water management; and (5) environmental aspects (Sullivan, 2003). The complexity of this approach, however, means that it is more suited for analysis at a local scale, where data is more readily available, than on a national level.

There is, therefore, no single definition of water scarcity; different measurements capture different aspects of the pressures on water resources, and there isn't one measure which captures them all. In terms of economics the need for water has to be expressed as a quantity and a price. This is called the "economic demand" for water and both quantity and price must be specified. Clearly, if a resource base is fixed and the consuming population increases, something has to give in. This will be either the price or the quantity of the resource used. However, even this system would ultimately be forced to a halt by population or economic growth. The economic system continues to grow due to the existence of substitutes for the scarce resource, at some reasonable cost. A paradox arises here because there is no substitute for non-saline water in sustaining human and animal life. But there is an almost infinite supply of sea water, which can be converted at a cost of energy into fresh water; so now energy, or the capital available to access the energy, becomes the limiting resource. Similarly, political boundaries, management skills, or human labor could be the factors which limit the availability of water.

The idea put forward by many that we are running out of water cannot be true globally, and even in specific water-short countries there is little doubt that water will always be available at some reasonable price, provided those countries follow sensible economic water policies. The definition of scarcity in non-economic terms is a distraction that can lead to major misallocations of the water resource (Rogers & Lydon, 1994). In the context of oil crisis Stavins makes the observation that the *"exhaustible resources are actually not threatened because their price reflects their scarcity; on the other hand, the renewable resources (such as clean water, forests and some biota) are most threatened due to mismanagement of these usually common property resources because they have no price protection".*

Allocation of water among the conflicting potential uses presents a major task to governments. It is difficult to assign unambiguous economic values to many uses, and hence these may be implicitly overvalued, undervalued, or completely ignored in the decision-making process. Rogers (Rogers P. , 1986) gives several examples of the problems that arise from undervaluing water. In particular, the existence of externalities and the lack of mobility of resources make finding the market price quite difficult.

In a perfectly functioning economy envisaged by the classical economic model "price equals value," and the cost of providing a good, after allowing for payments to all of its factors of production, will equal its market price. But equating cost with value only holds true in a perfectly functioning market economy. The value depends upon "to whom" and for "which use." The conceptual framework of treating water as an economic good is comprised of two components: the value of water and the cost of water. The interaction of these two components can decide the price of water. Alternatively, as per the scarcity principle the price for a scarce good should rise until an equilibrium is reached between supply and demand. In other words, the market price should be the scarcity value of the water.

2.5 Water Pricing

The European Commission in its WFD[14] has defined the '*water price'* as: *"The unit or overall amount paid by users for all of the services that they receive in terms of water, including the environment".*

It also mentions that *"Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex- III, and in accordance in particular with the polluter pays principle."*

In Article-9 i.e. recovery of costs for water services the said directive outlined that water pricing policies must reflect the following costs:

"Financial costs: *direct costs embracing the costs of supply and administration, operation and maintenance, and also capital costs.*

Environmental costs: *cost of the waste caused by water use on the ecosystem, for example: salination or degradation of productive soils.*

[14] Directive 2000/60/EC of the European Parliament, dated 23 October 2000, establishing a framework for Community action in the field of water policy binding on the European Union member states.

Resource costs: *cost of resource depletion leading to the disappearance of certain options for other users.*

Each user must bear the cost of consuming water. If pricing is to promote better water-resource use prices must be directly linked to the amount of water consumed and/or pollution produced."

Basing on the Dublin Principles[15] the concept of IWRM[16] was promoted by the Global Water Partnership (GWP) under which the concept and practices of treating water as an economic good was addressed by various management instruments including water. As per this concept the purpose of water pricing is three fold i.e.

(1) Cost[17] reflectivity: This should signal to users the true scarcity value of water and the cost of providing the service and provide incentives for efficient water use and give investors information on the real demand for any needed service extension. Pricing is the most cost effective means of meeting both demands and revenue needs;

(2) Environmental protection: Pricing encourages conservation and efficient use and recognizing environmental benefits from leaving water in its natural state;

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[15] Water has an economic value in all its competing uses and should be recognized as an economic good.
[16] Integrated Water Resources Management (IWRM) concept has been propagated by the Global Water Partnership (GWP). It has been accepted as an established principle for the development of water sector in more than 65 countries including India.
[17] "Price" and "cost" though often used interchangeably they have different meanings in business or economics. The technical definition of "price" is the amount of money to gain a product or service while "cost" is the amount paid to produce a product or service. "Price" implies future acquisitions of the buyer while "cost" refers to the money spent over various activities to make or maintain a product or service. But both refer to the element of money. In "price," money is used to gain something and "cost" refers to the money in the production process like labor, capital, materials, wages, bills, and other transaction costs. The "cost" is a component of the price. "Price" is demanded from the consumer while "cost" is demanded from the seller. For the seller, the "Price" is a future income and "cost "represents past expenses. Water as a commodity has a cost hence should have a price to achieve continued supply and service.

(3) Cost recovery: It helps in generation of revenues for the efficient operation, its future maintenance, modernization and expansion.

The background paper of GWP (Peter Rogers, 1998) on '*Water as a Social and Economic Good- How to put the principles in to practice*' have analyzed the details of water pricing that can be put in to practice. It differentiated the cost and the value of water and found that ideal sustainable use of water would require balancing of value and the cost of water. As per this paper the following are the components of cost and value of water.

<u>Components of Costs</u>

Full Supply Cost: - As per this document the full supply cost includes the costs associated with the supply of water to a consumer without consideration of neither the externalities imposed upon others nor of the alternate uses of the water and is composed of two separate items: Operation and Maintenance (O&M) Cost, and Capital Charges, both of which should be evaluated at the full economic cost of inputs.

$$\boxed{\text{Full Supply Cost = O \& M Cost + Capital Charges}}$$

O&M Cost:- Includes purchased raw water, electricity for pumping, labor, repair materials, and input cost for managing and operating storage, distribution, and treatment plants.

Capital Charges: - These include capital consumption (depreciation charges) and interest costs associated with reservoirs, treatment plants, and conveyance and distribution systems.

Full Economic Cost: - It is the sum of the Full Supply Cost as described in the previous section, the Opportunity Cost associated with the alternate use of the same water resource, and the economic externalities imposed upon others due to the consumption of water by a specific actor.

Full Economic Cost = Opportunity Cost + Economic Externalities

Opportunity Cost: - This cost addresses the fact that by consuming water, the user is depriving another user of the water. If that other user has a higher value for the water, then there are some opportunity costs experienced by society due to this misallocation of resources. The Opportunity Cost of water is zero only when there is no alternative use i.e. no shortage of water.

Economic Externalities: - As a fugitive resource, water results in pervasive externalities. The most common externalities are those associated with the impact of an upstream diversion of water or with the release of pollution on downstream users. There are also externalities due to over-extraction from, or contamination of, common pool resources such as lakes and underground water. There may also be production externalities due, for example, to the agricultural production in irrigated areas damaging the markets for upland non-irrigated agriculture, or forcing them to change their inputs. The standard economic approach to externalities is to define the system in such a way as to "internalize the externalities."

Positive Externalities occur, for example, when surface irrigation is meeting both the evapotranspiration needs of crops and recharging of groundwater aquifers. Irrigation is then providing an effective 'recharge service'. However, the net benefit of this "recharge service" will depend on the overall balance between total recharge (from rainfall and surface irrigation) and the rate of withdrawal of groundwater. Under conditions where groundwater is being "mined," the recharge from a surface system provides a net benefit that will be equal to the value of net additional crop output attributable to this additional volume of water. When the total recharge is greater than total withdrawal (but still does not result in a high groundwater table), the net benefit from the "recharge service" will be equal to the reduction in the cost of water pumping. This saving in costs may be small (equal to the cost of fuel or electricity) if it does not result in significant savings in investment costs as a result of a higher groundwater table. Hence, the net benefit of the positive externalities would have to be carefully assessed against the additional capital costs of reservoirs and/or the costs of conveyance and distribution of the "leaky" surface irrigation systems.

Negative Externalities may impose costs on downstream users if the irrigation return flows are saline, or where return flows from towns impose costs on downstream water users. One method used to account for these externalities is to impose a salinity levy on users, depending on their water use patterns. This is used in the Australian state of Victoria, and the surcharge is determined by the cost of restoring the saline water to its original condition (and is generally greater than the abstraction cost which users have to pay). Where return flows from towns impose costs on downstream users, one approach (in the German Ruhr and French systems, Briscoe 1995) is to levy a charge on urban consumers for restoring the wastewater to an acceptable condition. These negative externalities should result in additional costs to users who impose these externalities on others.

Full Cost: - The full cost of consumption of water is the Full Economic Cost, given above, plus the environmental externalities. These costs have to be determined based upon the damages caused, where such data are available, or as additional costs of treatment to return the water to its original quality.

Full Cost = Full Economic Cost + Environmental Externalities

Environmental Externalities: - The environmental externalities are those associated with public health and ecosystem maintenance. For example 'pollution' when it imposes a cost burden on the downstream users, it is an economic externality, but if it causes public health or ecosystem impacts, then it is an environmental externality. Environmental externalities are usually inherently more difficult to assess economically than the economic externalities.

Components of the Value of Water: For economic equilibrium, the value of water, which is estimated from the value in use should just equal the full cost of water for social maximization. Practically, the value in use is typically expected to be higher than the estimated full cost because of difficulties in estimating the environmental externalities in the full cost calculations. However, in many cases it may be lower than full cost, full economic cost, and even below full supply cost. This is often because social and political goals override the economic criteria.

The value of water depends both upon the user and to the use to which it is put. It may have the following components:

Value to users of water: - For industrial and agricultural uses, the value to users is at least as large as the marginal value of product.

Net Benefits from Return Flows: - **Return** flows from water diverted for urban, industrial, and agricultural uses constitute a vital element of many hydrological systems, thus the effects of these flows must be taken into account while estimating the value and cost of water (Briscoe 1996; Seckler 1996; Sinha, Bhatia and Lahiri 1986). For example, a part of the water diverted for irrigation may recharge the groundwater table in the region and/or increase the returns to the river/canal downstream. However, the benefits from the return flows will critically depend on the proportion of water that is "lost" to evaporation (due to open drains and canals) or to other sinks.

Net Benefits from Indirect Use: - The typical example of these benefits occurs with irrigation schemes that provide water for domestic use (drinking and personal hygiene) and livestock purposes, which can result in improved health and/or higher incomes for the rural poor. For example, in areas of northwest India (Haryana and western Uttar Pradesh) where groundwater is saline, irrigation canals not only provide water for domestic and livestock uses, water in these canals recharge the groundwater table, thus enabling the pumping of water from hand pumps and shallow tube wells

Adjustment for Societal Objectives: - For water use in the household and agricultural sectors, there may be an adjustment made for societal objectives such as: poverty alleviation, employment and food security (particularly in rural areas, where food grain prices tend to be high in the absence of the additional food output gained from irrigated agriculture, and where it may be difficult to supply imported food grains). Such adjustments are over and above the value of water to the user and should be added to reflect various societal objectives, as described in the section on irrigated agriculture. However, extreme care need to be taken in the use of these adjustments, with full consideration of the alternatives to meet these goals. The estimates of these values should be determined on the basis of the best available methods that give the real gains to the society from price differentials among sectors.

Intrinsic Value: - The concept of economic value, it should be noted, does not assign any value to concerns such as stewardship, bequest values, and pure existence values. While these are difficult to measure they are, nevertheless, valid concepts and do reflect real value associated with water use (or non-use).

2.6 The Effects of Reliability of Water Supply on Cost and Value:

The value of water depends crucially on the timing and reliability of the water supplies. Timeliness is most critical in irrigated agriculture where water shortages during critical stages of plant growth result in reduced crop yields. Lack of reliable irrigation supplies in public irrigation systems, particularly in South Asia, are responsible for low crop yields and farmers' lack of willingness to pay the full cost of water. Pumping of groundwater (e.g. in northwest India and Pakistani Punjab) improves timeliness and reliability of water input, and, hence, has resulted in relatively higher crop yields. For example, in four Indian states (Punjab, Haryana, Andhra Pradesh and Tamil Nadu), land-receiving groundwater irrigation produced roughly twice as many additional food grains per hectare as land receiving canal irrigation (Repetto 1994; Chambers 1988; Dhawan 1988) as reported by (Rogers P. , 1986).

2.7 Water Quality Concerns in Cost and Value:

As in the case of reliability, water quality influences both values and costs. The first three to four liters of water used for drinking purposes must be of the best quality and provide high value to the consumer as well as to society. Water for bathing, washing and personal hygiene need not be of the same quality as that used for drinking and cooking purposes. Flushing of toilets, cleaning, and gardening require varying qualities of water, resulting in differing levels of value, and hence willingness to pay. Industrial processes can use recycled water for process, cooling, and for transporting waste materials. Similarly agriculture needs differing water qualities, resulting in differing values and costs of provisioning the water. In particular, the demand for various water qualities for different uses provides incentives for recycling and re-use of water, with a view to matching demands with supplies.

2.8 Water as a Merit Good[18], Private Good[19] or Public Good[20]

C. J. Perry et al (C. J. Perry, 1997) in their Research Report titled *'Water Economic Good: A Solution or a Problem'* have brought out that water as a basic human need makes it a 'merit good' and considering it a social, economic, financial, and environmental resource makes the selection of an appropriate set of prices exceptionally difficult. Further, the application of price-based instruments, once an appropriate value system has been agreed, is particularly difficult in the case of water. This is so because the flow of water through a basin is complex, and provides wide scope for externalities, market failure, and high transaction costs. While judiciously applied market tools can be expected to have benefits, in many cases the necessary and sufficient conditions, especially defined and enforced water rights, are not yet in place. Priority attention to these essentials is likely to have high returns; pursuit of economic approaches in the absence of such preconditions may have unpredictable and possible negative effects. Since water serves many different objectives and has properties that make it both a private and a public good appropriate blend of values and facts in proper policy formulation for

[18] A commodity or service that is regarded by society or government as deserving public finance.

[19] An item of consumption that, if used by one party, may not be available for others, such as food and clothing etc. Its consumption is excludable and rivalrous.

[20] An item of consumption which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtractions from any other individual's consumption of that good. It is non-excludable and non-rivalrous in nature.

water requires a much more sophisticated form of analysis. While accepting water to be an economic good in most cases, like almost everything else they question if it is a purely *private* good that can reasonably be left to free market forces, or a *public* good that requires some amount of extra-market management to effectively and efficiently serve social objectives. The answer to this question lies not so much in lofty principles but in value judgments, and their application to different conditions of time and place. Thus they favor the private good side of the argument in some cases and the public good side in others.

John Briscoe in his keynote paper to ICID 1996 titled *'Managing Water as an Economic Good: Rules for Reformers'* analyzed urban water supply and irrigation and advocated for learning lesions from the various settings in the world where the theory has been put to practice with varying degree of success. He established a relationship between the supply cast and the opportunity cost as follows:

Figure 1: Pricing of urban utilities in most developing countries

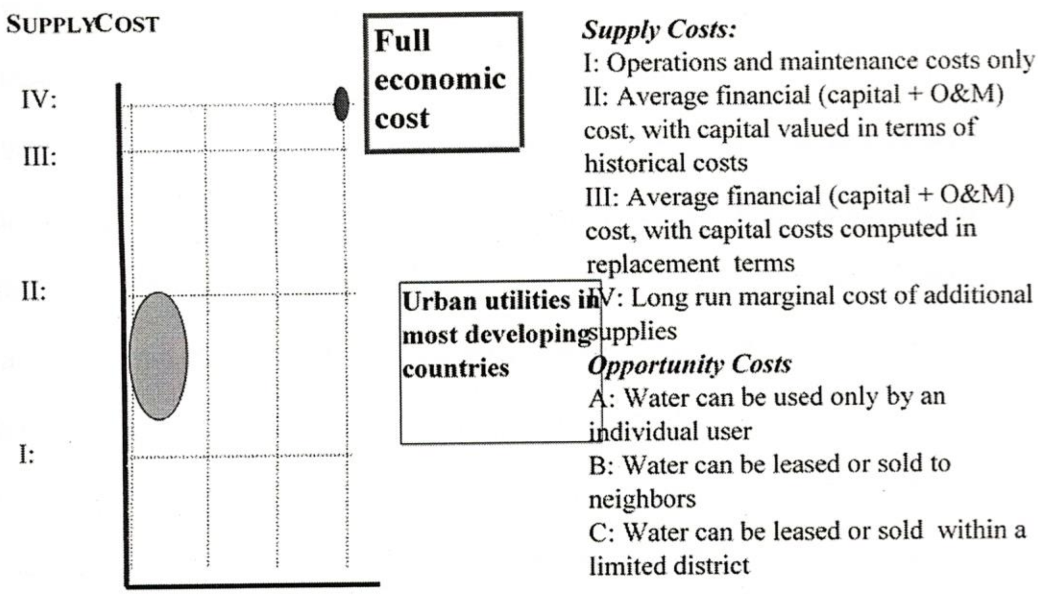
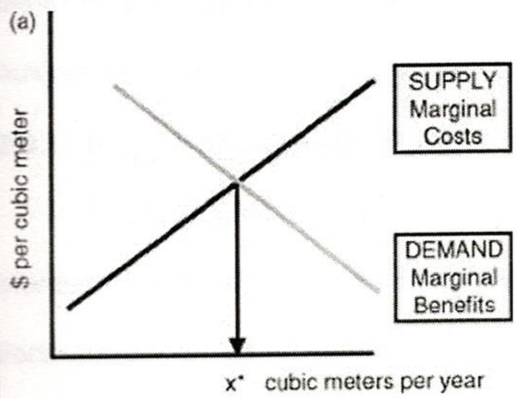
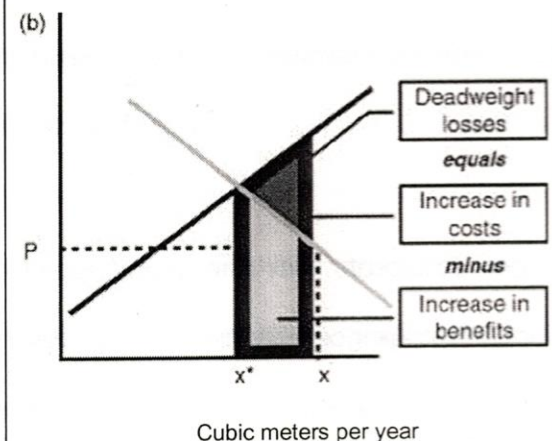


Figure 1 Urban Utilities in most Developing Countries

Figure 2:Marginal Cost Pricing in a Free Market



Optimal consumption at X' where demand and supply match in a free market



If the consumer is charged at a price P which is less than the marginal cost the consumption becomes X and creates a deadweight loss for the society.

He also showed the effect of underpricing in the above two illustrations where there is a deadweight loss in case of underpricing. He advocated marginal cost pricing in a free market.

2.9 Water Pricing Practice

When water is treated as an economic good, it has some unique properties like: non-substitution, renewal, scarcity, regional water supply and market monopoly, multisource of water supply, economic and social good properties. Treating water as economic good means to monetize water. The price of water is a response to the economic reality posed by the need to create and maintain a supply network, including treatment of the water. However, water isn't just a commodity, it also has social significance. Water is not free, but access to it is a human right essential for life itself. There is no point in thinking of water as free or unprofitable because this would greatly limit investment in distribution in many poor countries where water is only available for an hour each day. However, there is no point either in going to the other extreme and regarding it as a normal commodity for business as it is a survival need for all forms of life.

2.9.1 Pricing of Domestic Water

There is wide diversity of actual water prices and rate structures implemented by different water utilities, even within areas where geographical conditions are similar. The customer may be required to pay a connection fee to gain access to the water supply system. A service charge is often required to cover costs that are not related to the quantity consumed (like metering cost; in fact, service charges are also frequently called meter charges) or to guarantee cost recovery in situations where price differs from average cost. A quantity-related price is a consensual requirement for efficiency but in reality volumetric pricing can be implemented in a variety of ways. A survey of such pricing methods by Henerique Monteiro (Monteiro, 2005)has brought out the several models of pricing methods in vogue.

(i) Average vs. Marginal cost pricing

The oldest debate in the literature on water pricing is whether to price water by its average cost[21] or by its marginal cost[22]. Essentially, a resource is considered to be used efficiently if the benefit for society from consuming the last or marginal unit of the resource is the same as the cost of obtaining it (including the opportunity cost of foregoing other alternative uses). If the price of the resource is equal to its marginal cost, then the consumer can adequately compare the benefits he obtains

[21] Based on financial reasons of cost recovery.

[22] Based on the economic reasoning of promoting an efficient use of the resource.

with the costs he imposes with his consumption decision. If the unit price differs from marginal cost consumption levels will be either too high (for prices below marginal costs) or too low (for prices above marginal costs) in relation to the socially optimum level of consumption. Hirshleifer et al., (Hirshleifer, 1960) support the use of marginal cost pricing of water, opposing the practices of average cost pricing, for the efficiency reasons mentioned above. They also support price differentials for on-peak and off-peak demand. For example, seasonal peaks in water demand in the summer would require the introduction of a summer peak-load differential or surcharge in price. Riordan, (Riordan C. , 1971) compared typical average cost pricing techniques with her proposal of multistage marginal cost pricing and found that the latter was able to provide a 10-20% increase in total net benefits. Zarnikau, (Zarnikau, 1994) developed a model of spot market pricing for water (short-run marginal cost pricing), based on the electric power industry. Chambouleyron (Chambouleyron, 2003) compares both pricing schemes under different metering regimes (universal metering and optimal metering). He also shows that marginal cost pricing is always the most efficient pricing regime.

(ii) <u>Seasonal or temporal variations</u>

Gysi and Loucks (Gisy M. L., 1971) found out the advantages of an increasing block rate schedule combined with a summer price differential. The spot-market pricing system developed by Zarnikau, 1994 derives prices that vary with location and time (including time of day). Short-run marginal costs must include, besides operating costs, the costs imposed by capacity constraints or by the scarcity of water resources, to ration the available water to the highest value uses. However, such frequent changes may cause instability in the long-term decisions of customers like investing or not in water saving technologies. The adoption of this kind of pricing system would require the implementation of a communications system to keep customers permanently informed of the possibly frequent price changes, as well as more frequent meter readings, possibly through remote meter reading technology using telephone lines or cable television. Consumers are expected to respond to time-of-day- pricing or spot market pricing by changing their consumption from periods with higher prices to periods with lower prices. Finally, it should be noted that the model developed by Zarnikau, 1994 ignores the implementation costs of this water pricing system. For a spot-market water pricing system to be worth implementing its benefits must outweigh its costs.

(iii) <u>Capacity constraints or expansion decisions</u>

Riordan (Riordan C. 1., 1971) develops a model of optimal water pricing and investment by a publicly owned or regulated monopoly called multistage marginal cost pricing. The model is based on a short-run marginal cost pricing rule. When supply approaches capacity the price necessarily rises, keeping demand within capacity constraints. Dynamic programming techniques are employed to derive the optimal capacity expansions and their adequate timing.

(iv) <u>Scarcity</u>

Moncur and Pollock, 1988 deal with the problem of determining the scarcity rent of water. They consider the case of a water utility with groundwater as its only source, and use a nonrenewable resource efficient extraction model to determine the scarcity value and the efficient path of price in the future. They calculate the scarcity value through the consideration of the future increase in costs originated by the necessity to use costly technologies such as desalination or trans-basin diversions to satisfy water demand. They applied their model to Honolulu and find the scarcity value to be approximately twice the current water charge. An efficient price would have to equal marginal cost and the latter should include not only accounting costs but also opportunity costs reflected in the scarcity rent for water. This implies that efficient pricing of water in Honolulu would require its current price to triple.

(v) <u>Revenue requirements</u>

Marginal cost pricing does not ensure that the water utility generates enough revenues to cover costs including a reasonable amount of profit to guarantee the involvement of private firms in the industry. As per Zarnikau, 1994, marginal costs may fall below average costs in capital-intensive industries like water supply. Others, like Collinge, 1992 feel that due to use of cheaper sources of water before other more expensive sources, marginal cost can rise above the average cost of water supply. Using marginal cost pricing in a situation where average cost is lower than marginal cost can be an efficient way to raise revenues. Nevertheless, it is generally not allowed, because it has a '*regressive incidence*', hurting the poor the most, since water expenses have a greater weight in their budget. Hirshleifer et al. 1960 consider five alternatives to ensure financial viability of water utilities which adopt marginal cost pricing in a situation of natural monopoly (with declining average costs): government subsidies; voluntary contributions from customers to ensure water supply; declining block-tariffs; two-part tariffs; separation of customer classes which face different prices The authors favors the adoption of declining block tariffs first and two-part tariffs as a second choice.

(vi) <u>Metering</u>

Barrett and Sinclair (Barrett, 1999), investigate whether the policy of allowing households to choose if their water consumption will be metered is optimal or not and found that it may be efficient not to meter every customer and to have a dual system where the customer chooses if he should be metered or not (with non-metered customers paying higher fixed charges). Chambouleyron, 2003 combines the analysis of optimal water pricing and metering. Consumers are heterogeneous due to the variation in the numbers of household members. Four revenue collecting regimes are compared: - Ratable Value System (no metering is installed); Universal Metering; Optimal Metering (the socially efficient number of meters is determined in a centralized fashion); Decentralized Metering (the optimal number of meters is determined in a decentralized way by the company, which seeks to maximize profit).

(vii) Efficiency of block tariffs

Gysi et al (Gisy M. L., 1971) point out the advantages of an increasing block rate schedule combined with a summer price differential. Elnaboulsi (Elnaboulsi, 2001) develops a model of optimal nonlinear pricing of water and wastewater services. He considers the issues of temporal variation, capacity constraints, and scarcity and consumer heterogeneity. The author concludes that the optimal water tariff design is a two-part tariff (to recover operating/variable and fixed costs). If consumers are homogeneous a single two-part tariff should be implemented. In the presence of heterogeneous consumers a menu of two-part tariffs (with trade-offs between the fixed charge and the volumetric charge) must be implemented. Additional charges should be included in the unit price to reflect the scarcity value of water (in case there is a water shortage) or capacity constraints in any of the water supply and wastewater disposal facilities and transport systems.

(viii) Summary of the domestic water pricing methods

The studies on domestic water pricing by various researchers reveal the consensus that efficiency requires marginal cost pricing. However some divergence on whether we should consider short-run or long-run marginal cost pricing. The inclusion of the opportunity cost of water in the price when facing capacity constraints helps not only in deriving the optimal prices but also obtain the optimal timing for the expansion of the water supply system. Pure scarcity of the resource has become a concern only in more recent studies, reflecting the shift from the engineering perspective of increasing supply to satisfy demand to the economic perspective of also managing demand through price to efficiently allocate the existing quantity of water supply.

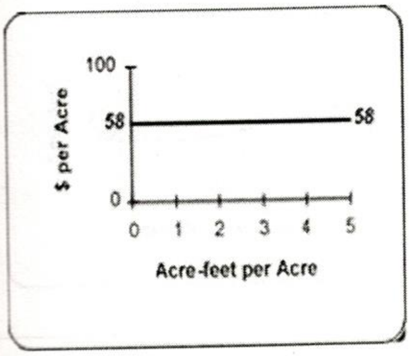
It is also accepted that pure marginal cost pricing may not be feasible or even desirable because of fairness, financial, political or legal reasons. Those concerned with fairness worry that marginal cost pricing could impose an undue burden on the poorest. In situations where the marginal cost falls below average cost, the revenue generated by marginal cost pricing may not be enough to recover the costs leading to financial losses by the water company. On the other hand, if marginal costs rise above average costs, excessive profits made through monopoly supply of what is perceived to be an essential good may not be acceptable to the public opinion or by legal standards. The most common ways of combining these two objectives are through the use of two-part tariffs, adjusting the fixed charge to meet the revenue requirement and second-best pricing for collecting the necessary extra revenue. This constrained versions of marginal cost pricing would still be preferable to other pricing schemes. Only a few studies have focused on the question of whether it is optimal to meter every customer, but they are unanimous in saying that, at least, there are conditions in which leaving some connections un-metered may be efficient.

Though the domestic water use accounts for only 5-8% of the total domain, its pricing is highly sensitive from socio-political reasons and the negative externalities created through such consumption. From sustainable development point of view its pricing must balance the social equity with the environmental externalities economically for attracting investments and improvement in service quality.

2.9.2 Pricing Irrigation Water

As per the FAO, agriculture accounted for 70% of water withdrawals in 2000 in the world and this percentage being more for the developing countries. In India, more than half of irrigated land is supplied with groundwater, providing one-third of the country's food production. Worldwide during the period from 1950 to 1995 the water withdrawal for agriculture has been doubled and likely to increase by 12% till 2025 (FAO, 2004). Hence pricing of irrigation water is important and should provide incentive for motivation to use water efficiently. Pricing can consist of a fixed charge (a constant fee assessed to landholdings or acres in production), a water rate (a price per-acre-foot of water delivered), or some mixture of the two. It should provide a direct relationship between farm deliveries and water bills so the incentive to take unnecessary deliveries is reduced and water will be used more efficiently. A good pricing should encourage efficiency, provide stable revenues, understandable and fair. There can be various rate schedules (Hydrosphere Resource Consultants, 1997):

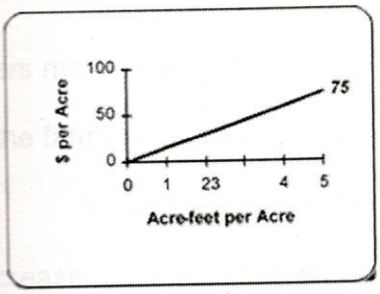
Figure3: Fixed Charge Only Rate Schedule



FIXED CHARGE = REQUIRED REVENUE/TOTAL ACREAGE

The drawback of this rate schedule is its lack of incentive to Efficiently manage water. Because a reduction in deliveries does not reduce the total water bill received by farmers, They see no direct benefit of lowering their total farm deliveries.

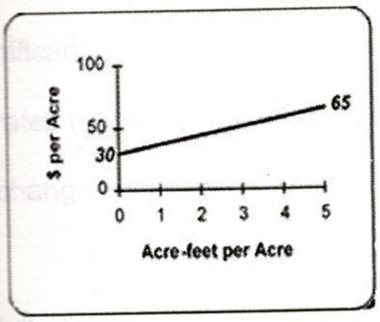
Figure 4: Water Rate Only Schedule



WATER RATE = REQUIRED REVENUE/TOTAL ANNUAL WATER DELIVERIES

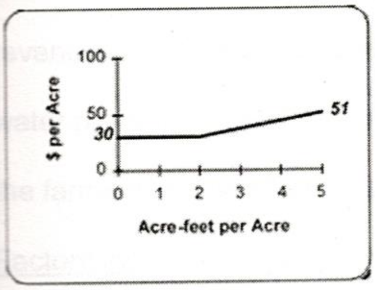
While this rate schedule promotes efficient u of water, it doesn't generate a stable revenue stream.

Figure 5: Combination Schedule



FIXED CHARGE = % FROM FIXED CHARGE X (R QUIRED REVENUE/ ACREAGE)+ WATER RATE = % FRO WATER RATE X (REQUIRED REVENUE/ANNUAL WAT DELIVERIES)

Figure 6: Fixed Charge with Free Block

	Generally free water is associated with this schedule. For fixed charges. But to recover the cost the tariff may be tiered rate where the rate is higher beyond the free block.

Elasticity

ELASTICITY = PERCENT CHANGE IN WATER USE/PERCENT CHANGE IN PRICE

The elasticity of water use to changes in fixed charges is very low as the farmers may not reduce their water use due to the increase in the fixed charges. In fact, the farmers might increase water use in an attempt to "get his money's worth." .

When there is a fixed charge and a water rate, economic theory says that increasing the fixed charge won't cause the farmer to reduce water use but increasing the water rate will. In practice, it's not so simple. If the farmer's total water bill makes up a small part of the farmer's total cost, then changes to either fixed charges or water rates will not elicit much response. On the other hand, if the total water bill is a significant part of the farmer's overall cost, then changes in either fixed charges or water rates (either of which cause the total water bill to increase) may cause the farmer to change water use.

If the total water bill is a large part of overall costs, then the increased water bill will cause a significant reduction in farm profits. The farmer may attempt to restore some or all of the lost profits by reducing costs. The farmer might reduce fertilizer use, increase mechanization to reduce labour costs, or, when there is a water rate, and reduce water use to reduce water costs. Water is as much a candidate for cost saving as any other farm input. The farmer's decision as to which input to cut back will be made on the basis of which will recover the most cost with the least impact on revenues. The farmer's sensitivity to changes in fixed charges increases as the total water bill makes up a larger proportion of total costs and as the overall profitability of the farming operation decreases.

Factors influencing Elasticity

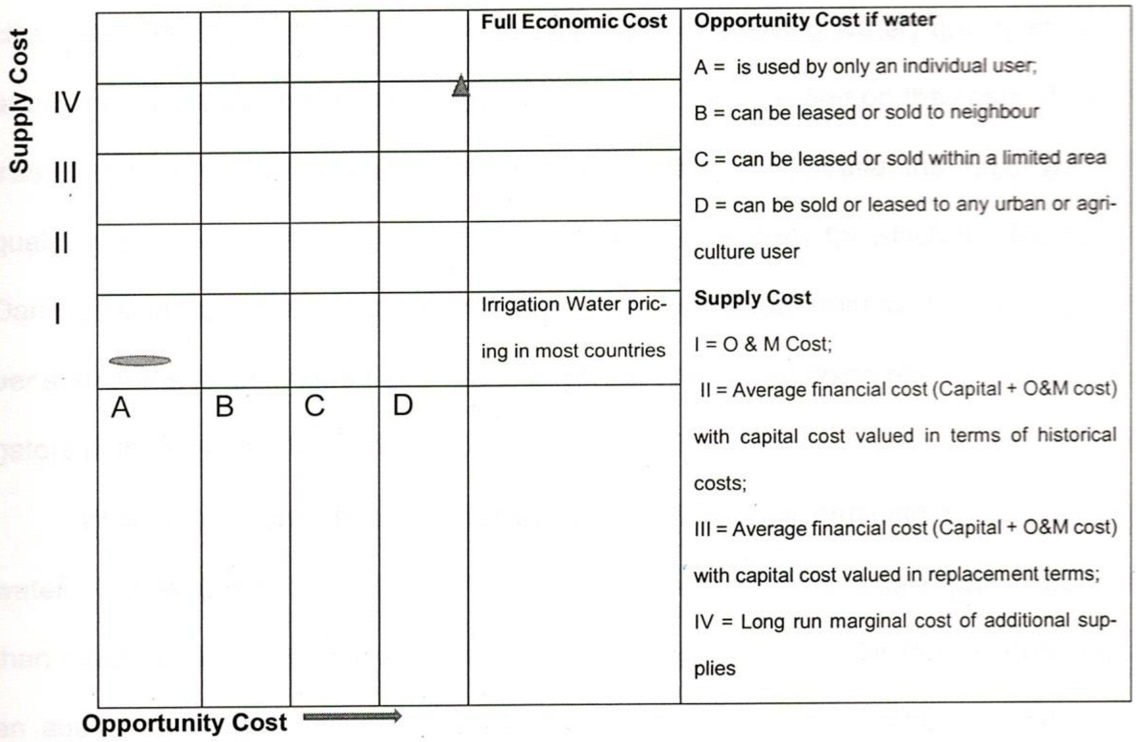
For agricultural water use, the short-run elasticity is much lower than the long-run elasticity. This is because the farmer has less flexibility to adjust water use over the course of one season than over several seasons. In the long run, the farmer can change the type of irrigation system or crop grown. During a single season or less, the farmer can only respond by cutting back on irrigations if the crop tolerates less water, or by maintenance of the irrigation system to keep efficiencies up. If the system is already well maintained and the crop is sensitive to dry conditions, there is not much that a farmer can do to respond to higher water rates. The important point to understand is that incentive pricing will have its greatest impact on water use over the course of several years. Other factors that affect elasticity are water from other sources, crop value, high production costs, soil types, water application rates, ability to change crops, ability to change irrigation technology etc.

These factors represent constraints on the farmer's flexibility to change irrigation practices. The less flexibility the farmer has, the lower the elasticity. The elasticity for agricultural water use is generally very low. It is difficult for farmers to immediately adjust their water use in response to increased water rates. Districts can expect small percentage decreases in water use over the first few years. Also, water rates in irrigation districts throughout the West are currently very low; therefore, a small increase in an already low water rate results in a large percentage change in the rate. A small percentage change in water use divided by a large percentage change in water rate equals a very small elasticity value.

Accounting for Opportunity Cost

As John Briscoe (Briscoe, Managing Water as an Economic Good- Rules for Reformers, 1997) the supply cost of irrigation water is usually modest, but when there is competition with either urban uses or high-value irrigation, the opportunity cost is high. In the Limari Basin in Chile, for example, the supply cost (which is partially subsidized) is about 0.5 US cents per cubic meter, whereas water trades at about 5 US cents per cubic meter. In California, a typical financial charge to an irrigator is about $5 per acre foot, whereas water trades at the equivalent of about $150 per acre foot. From the perspective of treating water as an economic good, the great challenge in irrigated agriculture is how to ensure that farmers take into account the opportunity costs, which are often an order of magnitude higher than current charges which is the essence of the appeal of the approach of water markets. There are many vital issues relating to charges for supply costs in irrigation. Experience has shown that cost recovery in and of itself achieves nothing, unless the money collected is used efficiently to improve the quality of services provided. He depicts the relationship between the supply costs to the opportunity cost as below:

Full Economic Cost for public irrigation Pricing of Water



He represented the negative externalities like pollution on downstream users who will have to incur additional treatment costs or the drainage water from irrigation fields carrying high levels of salts, nutrients and pesticides, leading to losses of aquatic habitats etc., as follow:

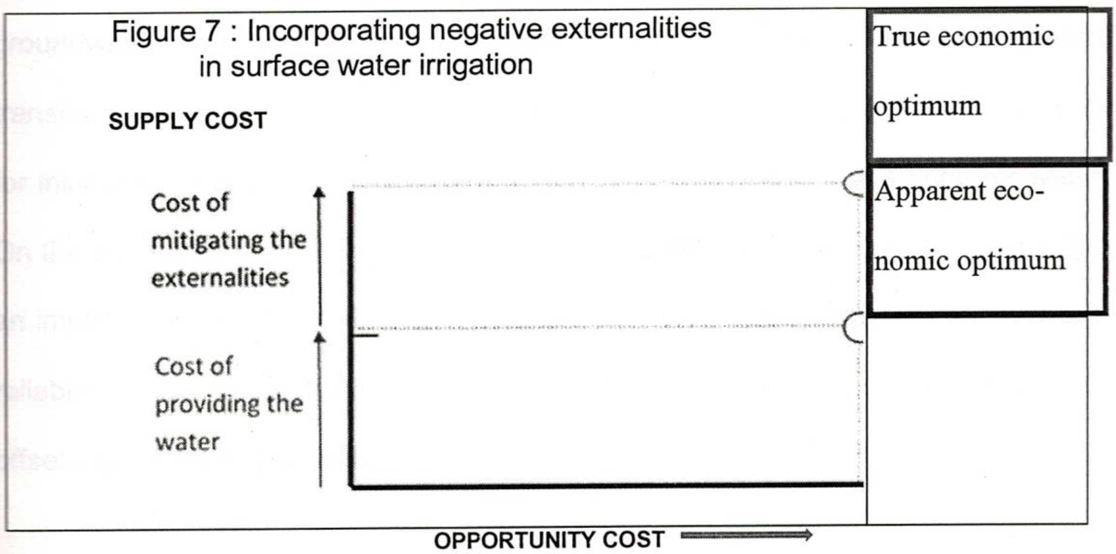
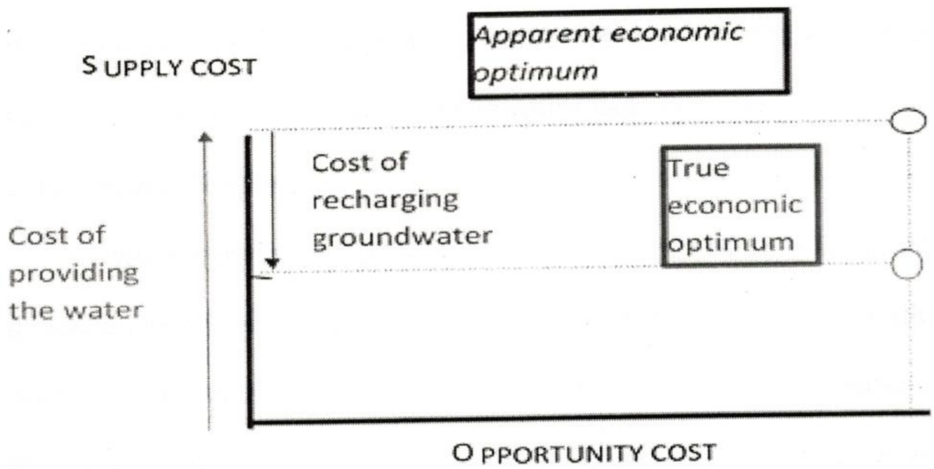


Figure 7 : Incorporating negative externalities in surface water irrigation

This system is evident in in the real world. For example, in many countries cities are required to meet specified wastewater (or receiving water) quality standards. The utility does this by treating its wastewater, and passing on the costs of this treatment to its customers. In the Murray-Darling Basin in Australia, the major water quality problem is the high levels of irrigation-induced salinity for which the Murray-Darling Basin Commission specified maximum salinity fluxes from its different member states due to which the costs of these control measures being passed on to irrigators in their water bills.

Briscoe also considered the positive externalities in determining actual cost of water. For example, farmers in the Gangetic Plain use more surface irrigation water than required due to evapotranspiration but recharging the aquifer thus performing an aquifer recharge service for farmers who use groundwater. What should the groundwater users pay the surface water irrigators for this service? An upper limit on this charge would be the cost of a formal recharge system (with which the groundwater users could recharge their aquifer). In such a case, the relevant charges to surface and groundwater users would be as below. In many circumstances, surface and groundwater users are the same population, in which case the notion of a monetary transfer from a user (to himself!) would not be sensible. In Indian irrigation systems, for instance, headwater and tail water users are charged the same price for water. On the one hand, since tail water users make greater use of groundwater, they "get an implicit subsidy" from the headwater users. On the other hand, the quantity and reliability of the service to the headwater users is far superior, probably more than offsetting the implicit subsidy.

Figure 8: Incorporating the positive externality in surface irrigation



Irrigation water is commonly priced volumetrically or using a flat rate or fixed charge. A special case of volumetric pricing is marginal cost pricing which requires metering of water use (which makes it suited to pumped water supplies such as tube wells. A review of World Bank policy and practices recommends that for efficient use, irrigation water is priced volumetrically, based on opportunity costs. Where this is not feasible (e.g. for gravity-fed systems and canal irrigation), water can be charged for at a flat rate or a fixed charge. The charges are based not on the amount of water used but on other variables such as the land area, value of landholding, crop output, or non-irrigation inputs (e.g. land improvements). The most common form of charging is based on land area, as this is easy to administer and suited to continuous flow irrigation. Since, farmers place high marginal values on irrigation water, often a number of times higher than the charges actually imposed (Repetto, 1986 as reported by FAO) increase in charges may not affect demand where these marginal values are so high. On the other hand, under-pricing can be expected to encourage wastage of water, poor maintenance of irrigation systems and inefficient applications of water, resulting in reduced agricultural output. Failure to set water charges for irrigation on the basis of either opportunity costs or user benefits has been a classic cause of inefficiency in the agriculture sector. Therefore, proper valuation of the socio-economic benefits derived from water resources is an important and often necessary condition for efficient and sustainable water resource use.

2.10 Water Trading

Water trading is a voluntary exchange or transfer of a quantifiable water allocation between a willing buyer and seller. In a water trading market, the seller holds a water right or entitlement that is surplus to his current water demand, and the buyer faces a water deficit and is willing to pay to meet his water demand. They can be allowed to trade in case appropriate law and institutions are in place. For water markets to be functional there should be voluntary buyers and sellers, allocation of vested rights, proper information, clear definition of rights, transferable from land rights and changeable types of water use. Such trade face constraints from high cost of infrastructure, high transaction cost and political and social barriers. However, the important benefit of water trading is that it establishes a value of water. This price gives users a signal about the value of water in alternative uses and encourages efficient use patterns and conservation. The equilibrium value of water also gives public and private investors information about what new supply projects should be built. Such water trading practices have been introduced in Murray-Darling basin in Australia, Chile, Arizona and California in USA etc.

2.11 International Experiences of Water Pricing

A study by the World Bank (World Bank, 1997) shows that countries have different reasons for charging for water, including cost recovery, redistribution of income, improvement of water allocation, and water conservation. Pricing schemes often comprise both fixed and variable components. Fixed prices vary greatly across countries, reflecting countries' various objectives in charging for water. However, volumetric charges for urban and agricultural water are relatively similar across countries. But per meter charges for industrial water vary more widely across countries, reflecting the different use of subsidies and the inclusion of pollution taxes that vary by industry. For urban and agricultural water, all developing countries, and some developed countries, set charges on the basis of average rather than marginal cost of supply. Countries do not generally adjust charges by region even though the costs of supplying water may vary greatly across regions. Agricultural water users generally pay something for the operations and maintenance costs of irrigation systems, ranging between 20-75 percent of total costs. Few countries attempt to recover capital costs from users. The willingness of countries to undertake water pricing reforms and successfully implement them cannot be solely explained by their water scarcity levels nor by the size of their budget deficits. However, high income countries are relatively more open to reforming water pricing policies. Almost all country reports discuss the need for volumetric pricing, metering, moving away from uniform tariffs, and abolishing minimum prices. Many specify the need to significantly increase water charges to all users. Several country reports discuss the use or the need to use of measures, such as pollution taxes, to protect the environment. Several countries recognize the need to provide incentives to water suppliers and consumers. The survey also found out that in many countries the users paid full cost of water prior to 1950. Interestingly, the farmers in India and Pakistan paid for irrigation water fully prior to 1950. However, the recovery of cost is very low afterwards which is between 20 to 30 % of the O&M cost while in Madagaskar it is 75%. No country had included the depreciation in the cost though Canada and Brazil were trying to recover a portion of the capital cost.

2.11.1 Brazil

As water is considered to be an economic good, tariffs are seen as a means to encourage its efficient use of water and as a means of raising revenue for financing programmes and activities within the water resource plans. To overcome concerns that tariff would be used as "another tax", revenue from tariff are required to be invested in the River Basin in which they were generated and a maximum of 7.5% of tariff revenue can be used to cover administrative overheads.

2.11.2 Melbourne, Australia

Melbourne Water uses a detailed average cost model to allocate costs between the five retail water businesses it supplies. Costs are identified separately for head works (water harvesting and storage) and the transfer system (pipes and pumping stations). The total costs to be recovered include a return and depreciation on the Regulatory Asset Value (RAV) allocated to each part of the supply system, along with direct operating costs and an allocation of overheads.

2.11.3 South Africa

The general principles upon which the calculation of the bulk water tariff is based are: (1) Full cost recovery ;(2) Long-term sustainability of the service; and (3) financial ring-fencing of the service.

2.11.3 China

The price of water in Beijing, for example, reflects a number of different cost items like water resource fee (for both surface and groundwater), a sewage treatment fee, a tap water fee to cover the fixed and variable (capital and O&M) costs of the water supply company, and a tax of the Beijing municipality as per the China's Price Law and the National Guidelines on Water Tariffs.

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